ASTROBIOLOGY EXPLORATION STRATEGIES FOR THE MARS POLAR REGIONS USING BALLOON PLATFORMS. P. R. Mahaffy[1], S. A. Atreya[2], D. A. Fairbrother[3], W. M. Farrell[1], S. Gorevan[4], J. Jones[5], I. Mitrofanov[6], and J. Scott[7], [1]NASA Goddard Space Flight Center, Greenbelt, MD 20771, Paul.R.Mahaffy@gsfc.nasa.gov, [2]University of Michigan, Ann Arbor, MI, [3]Goddard Wallops Flight Facility, [4]Honeybee Robotics, New York, New York, Wallops, MD, [4]Jet Propulsion Laboratory, Pasadena, CA, [5]Space Research Institute, Moscow, Russia, [6]Carnegie Institution, Washington, DC.

Introduction: Montgolfiere balloons can provide a unique near-surface platform for an extended traverse over the polar regions of Mars. During the polar summer, such solar powered balloons would remain in the constant sun of the polar summer and could remain airborne for many weeks or even months as the atmospheric circulation would drive the balloons around the polar region many times before the balloon would cross the terminator. Such a platform for scientific measurements could provide in situ sampling of the atmosphere for trace disequilibrium species that might be indicators of present geological or biological activity in this region. It could furthermore provide high resolution imaging, deep electromagnetic (EM) sounding for subsurface stratigraphy and liquid water, and high spatial resolution neutron measurements of subsurface ice. Technologies for robust balloon deployment on entry and controlled encounters with the surface and near subsurface for sample acquisition in otherwise inaccessible regions (Figure 1) are presently being studied and developed with support from NASA.

Pointers to Past or Present Life on Mars: Potential indicators or pointers to ***present life*** in the Martian polar region might be found in the atmosphere in the form of non-photochemically produced species such as trace levels of methane or formaldehyde that might be produced by low levels of near-surface biological activity. The near-surface cryosphere and subsurface aquifers, if they were to exist in the polar region, might provide ecological niches for hardy microbial life. Pointers to ***past conditions on Mars that might have been more conducive to the nourishment of life*** may also be measured in the atmosphere in the form of isotope ratios of light isotopes of carbon, nitrogen, and the noble gases. Their isotopic composition address mechanisms of obtaining the present atmosphere through loss to the surface and space and production through infall and volcanic activity. Likewise, the surface stratagraphic record of the near polar region might be able to reveal elements of its glacial, geological, and climate history[1]. All of these diverse measurements could be implemented from a balloon platform in a future mission to this region.

Unique Characteristics of a Balloon Platform: Key mission elements to complete the astrobiology related science objectives sketched in the previous paragraph are (1) regional mobility over; (2) proximity to; and (3) long duration over the volatizing polar cap. A balloon can float just kilometers above the surface with slow speeds of several m/sec providing the needed mobility, proximity, and dudration. There is a substantial usable science mass with such a platform and platform-unique science features. With an appropriate complement of space-proven instruments these could include:

- An in situ atmospheric chemistry laboratory to search for local sources of anomalous trace species in an extended region over a summertime volatile-producing ice cap.
- A platform positioned well below the attenuating ionosphere to perform radio sounding of the ice cap and the polar layered terrain.
- Imaging with better than 11 cm resolution from an altitude of 4 kilometers and higher resolution in near surface flights.
- Higher order magnetic moments beyond dipole values, of surface magnetic features.

Figure 1. Balloon sampling may enhance our ability to carry out exploration over rugged landscapes on Mars such as the polar caps and erg. Under development for solar driven Montgolfiere balloons is the ability to approach the surface for rapid acquisition with a “touch-and-go” sampler.

- The ability to perform targeted stratagraphic studies of erosion features like Chasma Boreale.
- Neutron mapping of shallow water ice with <3 km horizontal resolution from a balloon at 4 km altitude, ~200 x better spatial resolution than the Odyssey global map.

Balloon Technology Studies: Key balloon technology elements to insure robust implementation of such an investigation continue to advance.

Balloon Deployment Studies. Recent tests at JPL have demonstrated balloons autonomously deployment from the ground or while falling from high altitudes[2,3]. The stratospheric deployment tests, which are more likely anticipated for Mars (Figure 2), are still ongoing, but have been generally successful for polyethylene balloons, although there have been two failures of large balloons due to deployment issues. For these stratospheric tests, a packed Montgolfiere balloon is lifted to 36 km altitude (4 mbar) by a helium balloon. The packed Montgolfiere is then allowed to fall on a parachute at 50 m/sec and is deployed from the bottom of the bag. For a a double Montgolfiere deployment, the empty Montgolfieres fill while falling and are rapidly heated by the Sun, thus providing buoyance. Current development activities include selection of optimal balloon materials, balloon fabrication techniquess, and packing as well as optimization of the deployment sequence to increase the robustness of the deployment.

Controlled Surface Access. Several altitude-controlled tests have also been successfully conducted using black plastic Montgolfiere balloons. In the first field test in California's Mojave Desert in 1998, a radio-controlled vent was placed at the top of the balloon. When the vent was opened, hot air was released and the balloon descended. Conversely, closing the vent caused the balloon to ascend. This initial successful flight of about 15 minutes was followed by a much longer flight over the Pacific Ocean later that year. During this ocean test, the balloon was allowed to climb to about 1 km altitude, and the vent periodically opened to allow descent. The balloon payload was actually soft-landed on the ocean several times before the test was terminated. Post-flight thermal analysis very closely agreed with actual balloon behavior during the entire flight. Development of the next generation autonomous altitude control mechanism is underway.

Sample Acquisition Sudies. A rapid "touch & go" sample acquisition system has been developed[4] and is being tested and refined. This device is is specifically designed to be deployed from a moving platform such as a balloon to provide very rapid acquisition of material from the surface and to some depth below the surface of Mars. Such a balloon/sampler system could enable collection of materials for analysis from a variety of sites in otherwise difficult to reach locations.

References: (1) Clifford, S. M., et al., "The State and Future of Mars Polar Science and Exploration," Icarus, 144, 210-242. (2000). (2) J. A. Jones and J. J. Wu, "Solar Montgolfiere Balloons for Mars", AIAA #99-3852, 1999. (3) J. A. Jones, "Mars Rover Balloon Launch", JPL Video#9910_06, October 1999. (4) S. Rafeek, K. Y. Kong, S. P. Gorevan, and M. A. Ummy, A Balloon Delivered Subsurface Sample Acquisition and Transfer System, Concepts & Approaches for Mars Exploration, Lunar and Planetary Institute, Houston, TX, July 18-20, 2000.

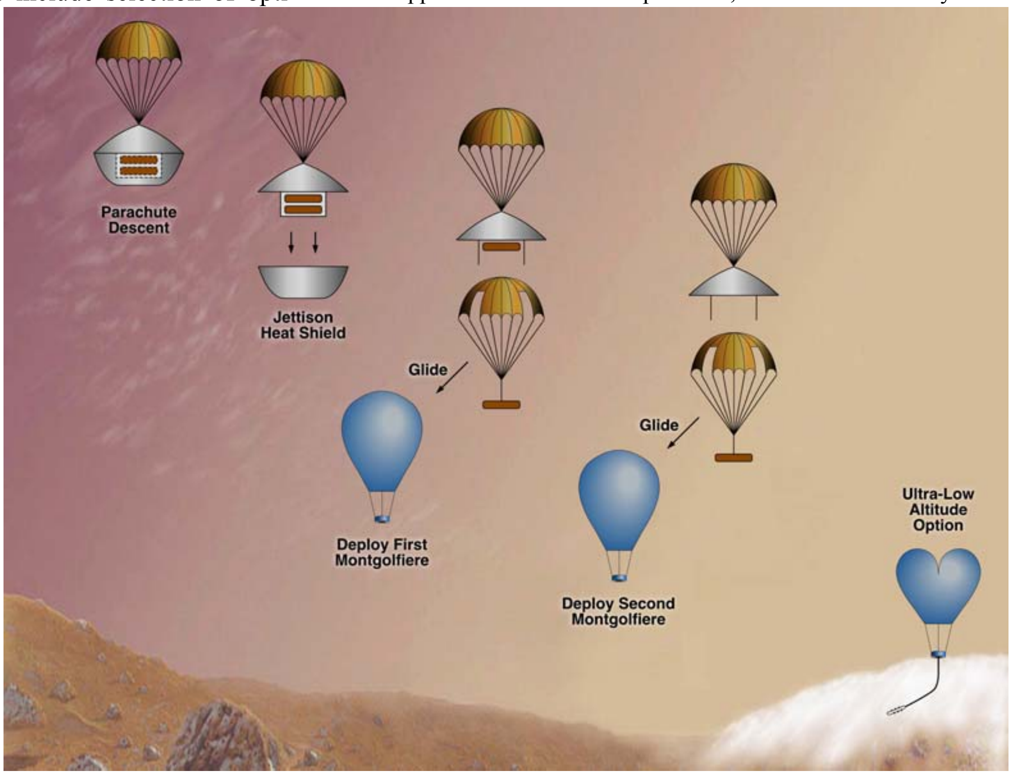

Figure 2. In a deployment scenario studied for a future Mars mission, two Montgolfiere balloons rapidly fill and heat while falling through the atmosphere. Altutude control devices may allow surface soil and ice sampling.